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(54) **ARTICLE WITH ELECTRONIC COMPONENT INCLUSION**

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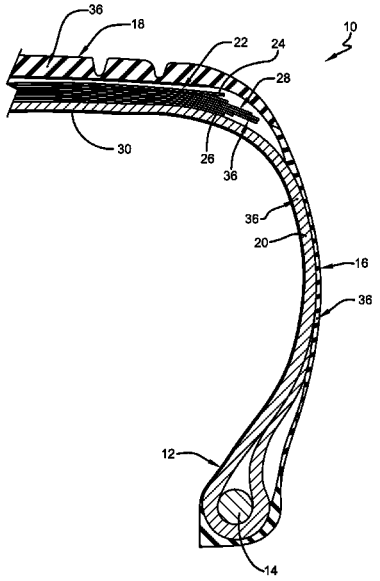
(57) **ABSTRACT**

An article that experiences repeated deformation includes an electronic component as an inclusion. The article includes at least one structural element, in which the structural element includes a material. At least one electronic component is incorporated into the material as an inclusion. The electronic component includes an integrated circuit and may also include at least one sensor and an antenna. The size of the electronic inclusion is no greater than the largest inclusion typically occurring within the material. The article may be an article formed of rubber, such as a tire.

19 Claims, 3 Drawing Sheets



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H05K 7/02	(2006.01)
B60C 23/20	(2006.01)
B29D 30/00	(2006.01)
B60C 19/00	(2006.01)

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USPC 73/146–146.8

See application file for complete search history.

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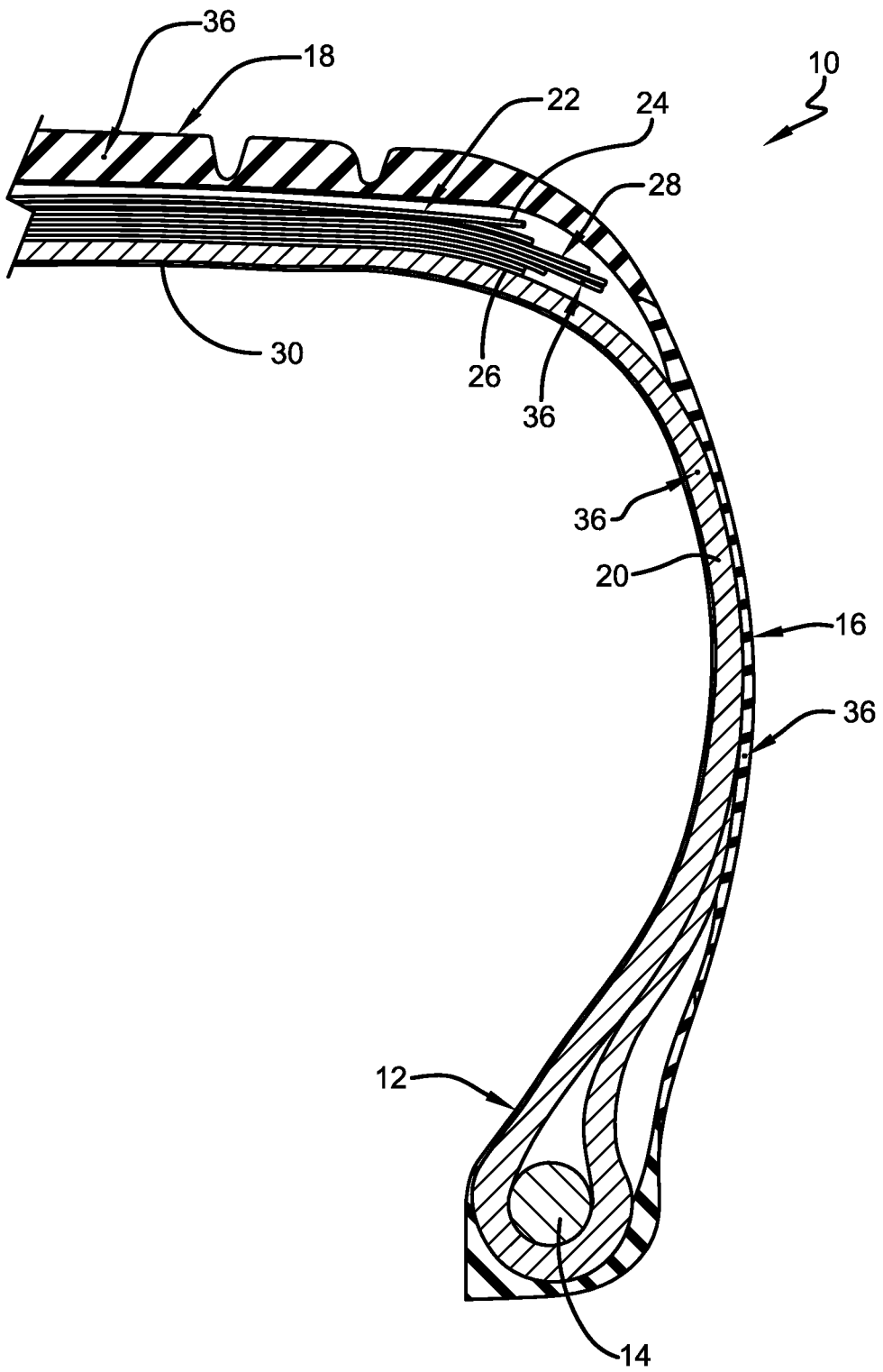

FIG. 1

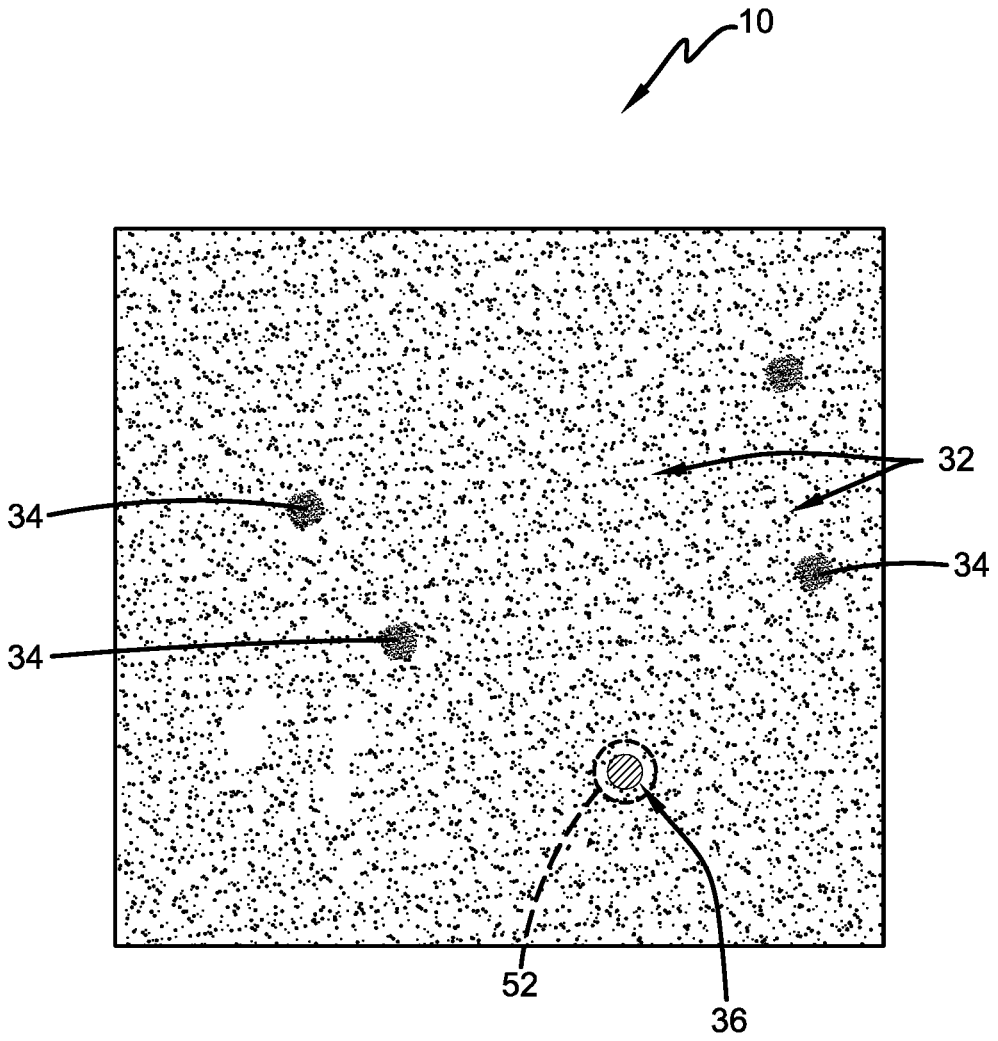

FIG. 2

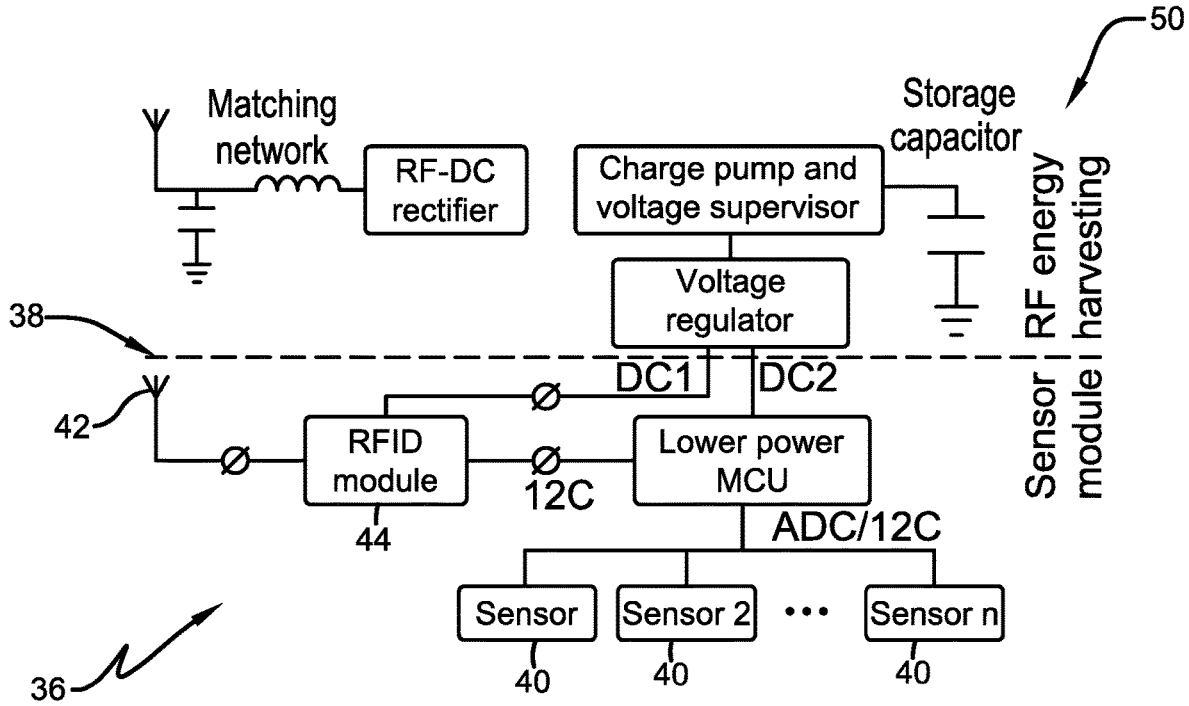
50
Matching network
RF-DC rectifier
Charge pump and voltage supervisor
Storage capacitor
Voltage regulator
38
RF energy harvesting
Sensor module
DC1
DC2
42
RFID module
12C
Lower power MCU
44
ADC/12C
Sensor
Sensor 2
Sensor n
40
40
40
36

FIG. 3

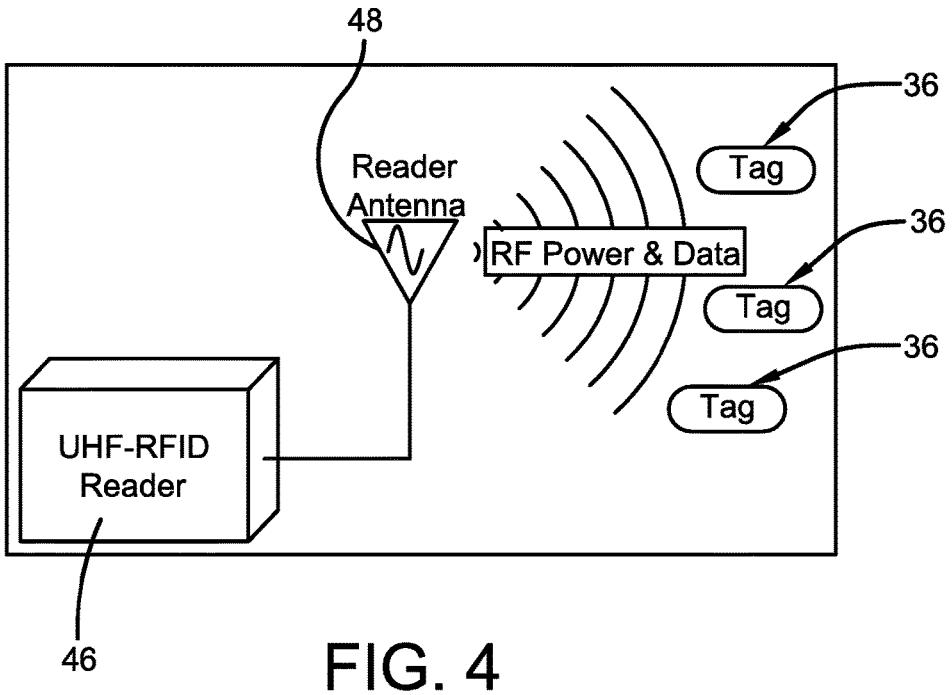
48
36
Reader Antenna
Tag
RF Power & Data
36
Tag
36
Tag
UHF-RFID Reader
46

FIG. 4

ARTICLE WITH ELECTRONIC COMPONENT INCLUSION

FIELD OF THE INVENTION

The invention relates to articles that experience repeated deformation, such as tires. More particularly, the invention relates to electronic components that sense various conditions within an article that experiences deformation. Specifically, the invention is directed to an article that includes an electronic component that is incorporated into the material of a structure of the article as an inclusion.

BACKGROUND OF THE INVENTION

Many articles, such as tires, experience repeated deformation. For example, articles that experience repeated deformation include any type of tires, such as pneumatic tires, non-pneumatic tires, automotive tires, passenger tires, truck tires, commercial tires, off-the-road tires, aircraft tires, spacecraft tires, and the like, as well as buildings, bridges, shoe soles, medical devices, rubber engineered products such as air springs and vibration mounts, bearings, sealants, adhesives, and the like. Reference herein is made to a pneumatic tire by way of example, with the understanding that the invention applies to any article that experiences repeated deformation.

In the manufacture of a pneumatic tire, the tire is typically built on the drum of a tire-building machine, which is known in the art as a tire building drum. Numerous tire components are wrapped about and/or applied to the drum in sequence, forming a cylindrical-shaped tire carcass. The tire carcass is then expanded into a toroidal shape for receipt of the remaining components of the tire, such as a belt package and a rubber tread. The completed toroidally-shaped unvulcanized tire carcass, which is known in the art at that stage as a green tire, is then inserted into a mold or press for forming of the tread pattern and curing or vulcanization.

Each of the tire components is made of a material that includes an elastomer compound, and certain components may be reinforced with other materials depending on specific design and performance requirements. For example, the belt package includes layers of strips of rubber that are reinforced with cords, and the tread is typically an elastomer compound that may be reinforced with particulate materials.

For many modern tires, it is often desirable to mount electronic components to the tires either before or after curing. Such electronic components enable the temperature, pressure and/or other parameters of the tire to be continuously monitored during vehicle operation. All modern electronic components include an integrated circuit that processes and stores information. One or more sensors are integrated with or electronically connected to the integrated circuit. An antenna for receiving and transmitting a signal to an external reader is also electronically connected to the integrated circuit, and may be carried on a substrate with the integrated circuit.

In the prior art, such electronic components have typically been attached to the inside surface of a pneumatic tire, which defines the cavity containing the inflation gas. Such a location has enabled the electronic components to continuously sense parameters such as the temperature and pressure inside the tire cavity, while not interfering with the structure of the tire. More particularly, prior art electronic component units for tires have typically been about 5 to 10 millimeters (mm) thick by about 20 to 25 mm in diameter. Because the integrity of the tire components is important, the size of prior art electronic component units has dictated placement on the inside surface of the pneumatic tire, and thus inside the tire cavity.

While prior art electronic component units are acceptable for many uses, it is desirable to monitor the actual temperature and other parameters at specific structural locations inside the tire structure during use on a vehicle or on a dynamic tire testing apparatus. For example, monitoring the actual temperature at the edge of the belts in the belt package would be advantageous in predicting ongoing tire performance and potential tire replacement, as well as in providing immediate information to a driver or dispatcher to adjust the speed of a vehicle before potential thermal damage to the tire may occur. However, accurate measurement of the actual temperature at such a location requires the electronic component unit to be permanently embedded into the tire interior structure. Due to the size of prior art electronic component units, any permanent embedding of such units into the tire interior structure may undesirably impair the structure of the tire by potentially creating stress risers, which may compromise the fatigue resistance of the tire.

Other prior art techniques of measuring the interior temperature of tires at specific locations has included inserting needle-like temperature-measuring probes into the structure of the tire until the tip of the probe reaches the desired location. Such prior art techniques are not suitable for monitoring temperature during tire use, since the tire has to be stationary while the needle is inserted and removed.

As a result, it is desirable to develop an article, such as a tire, which includes an electronic component that is integrated into the structure of the article without adversely affecting the performance or life of the article.

SUMMARY OF THE INVENTION

According to an aspect of an exemplary embodiment of the invention, an article with an electronic component inclusion is provided. The article includes at least one structural element, in which the structural element includes a material. At least one electronic component is incorporated into the material as an inclusion, and the electronic component includes an integrated circuit.

Definitions

"Axial" and "axially" mean lines or directions that are parallel to the axis of rotation of the tire.

"Axially inward" and "axially inwardly" refer to an axial direction that is toward the axial center of the tire.

"Axially outward" and "axially outwardly" refer to an axial direction that is away from the axial center of the tire.

"Bead" means that part of the tire comprising an annular tensile member wrapped by ply cords and shaped, with or without other reinforcement elements such as flippers, chippers, apexes, toe guards and chafers, to fit the design rim.

"Carcass" means the tire structure apart from the belt structure, tread, undertread, and sidewall rubber over the plies, but including the beads.

"Circumferential" means lines or directions extending along the perimeter of the surface of the annular tread perpendicular to the axial direction.

"Cord" means one of the reinforcement strands of which the plies in the tire are comprised.

"Equatorial plane (EP)" means the plane perpendicular to the tire's axis of rotation and passing through the center of its tread.

"Innerliner" means the layer or layers of elastomer or other material that form the inside surface of a tubeless tire and that contain the inflating fluid within the tire.

"Radial" and "radially" mean lines or directions that are perpendicular to the axis of rotation of the tire.

"Radially inward" and "radially inwardly" refer to a radial direction that is toward the central axis of rotation of the tire.

"Radially outward" and "radially outwardly" refer to a radial direction that is away from the central axis of rotation of the tire.

"Radial-ply tire" means a belted or circumferentially-restricted pneumatic tire in which the ply cords which extend from bead to bead are laid at cord angles between about 65 to about 90 degrees with respect to the equatorial plane of the tire.

BRIEF DESCRIPTION OF DRAWINGS

The invention will be described by way of example and with reference to the accompanying drawings, in which:

FIG. **1** is a schematic cross-sectional view of an exemplary article of the present invention;

FIG. **2** is a representation of the microstructure of a vulcanized rubber compound of a structural component of the article shown in FIG. **1**;

FIG. **3** is a circuit diagram of an exemplary electronic component incorporated into a compound of the article shown in FIG. **1**; and

FIG. **4** is a schematic representation of a reader and the exemplary electronic component shown in FIG. **3**.

Similar numerals refer to similar parts throughout the drawings.

DETAILED DESCRIPTION OF THE INVENTION

An exemplary embodiment of an article of the present invention is indicated generally at **10**, and is shown in FIG. **1**. By way of example, the article **10** is shown and described herein as a tire **10**, with the understanding that the invention applies to any article that experiences repeated deformation. The tire **10** includes a bead area **12** and a bead core **14** embedded in the bead area. A sidewall **16** extends radially outward from the bead area **12** to a ground-contacting tread **18**. The tire **10** is reinforced by a carcass **20** that toroidally extends from one bead area **12** to a second bead area (not shown), as known to those skilled in the art. The carcass **20** includes at least one ply that preferably winds around each bead core **14**.

A belt reinforcement package **22** is disposed between the carcass **20** and the tread **18**. The belt reinforcement package **22** may employ specific configurations as desired. For example, the belt reinforcement package **22** may include at least one of a radially outer belt structure **24** and a radially inner belt structure **26**, and an intermediate belt structure **28** disposed between the radially outer belt structure and the radially inner belt structure. In the prior art, an integrated circuit/sensor/antenna unit (not shown), which would be about 5 to 10 mm thick by about 20 to 25 mm in diameter, would be attached to an innerliner **30**, which is the layer that forms the radial inside of the tire **10**.

With additional reference to FIG. **2**, the tread **18** of the tire **10** includes a material that in turn includes an elastomer compound **32** which may be reinforced with a predetermined amount of rigid particulate inclusions **34**, such as carbon black and/or silica. The inclusions **34** are dispersed throughout the compound **32** and typically include a size of up to about 500 microns or about 0.5 millimeters (mm) in diameter.

In addition, the compound **32** may include a limited amount of other particulate inclusions (not shown), such as particles of dirt or sand. Those particulate inclusions may be up to about 2,000 microns or about 2 mm in diameter. While the size of such dirt or sand particulate inclusions may be larger than the particulate inclusions **34** of carbon black or silica, the amount of such inclusions is limited and the tire **10** is designed to account for a certain amount of them.

Therefore, the design of the tire **10** allows for a predetermined number or amount of inclusions **34** in the tread compound **32** that are up to about 0.5 mm in diameter, and for a limited number of inclusions that are up to about 2 mm in diameter. It is to be understood that the compound **32** of the tread **18** is shown and described by way of example, as the invention applies to any material or compound of a component or structure of the tire **10**, including components of the sidewall **16**, the carcass **20**, the belt reinforcement package **22**, the innerliner **30**, and the like, as well as other articles that experience repeated deformation.

In accordance with a feature of the invention, the tire **10** includes an electronic component **36** that is incorporated into the material of the tire, such as compound **32**, as an inclusion. It is to be understood that the term inclusion as used herein means a component that is integrated into a compound of a component of the tire **10** as a rigid particulate that is under 2 mm in diameter. For example, the electronic component **36** is as small as possible, and may be up to about 0.2 mm in diameter or about 0.5 mm in diameter, as forming techniques (to be described below) dictate. The maximum size of the rigid electronic component or components **36** in such a size preferably is no larger than inclusions already existing in the compound, and therefore will not reduce the resistance of the tire **10** to mechanical fatigue during repeated mechanical deformations.

In non-rubber articles that experience deformation, the size range may be different than that described above, with the understanding that the present invention is directed to a size of the electronic inclusion **36** being no greater than the largest inclusions or grain sizes that are usually present in the material of the articles. It is to be understood that the term "diameter" as used herein is by way of convenience, as the electronic inclusion may be of any geometric shape known to those skilled in the art, including any circle, sphere, polygon, polyhedron, and the like.

The electronic component **36** preferably is formed by micro-assembly techniques, such as three-dimensional (3D) printing. For example, micro-3D printing techniques have been developed that reduce the size of integrated circuits and other electronic components to a range of under 2 mm in diameter. Such techniques are described in greater detail in published International Application No. WO2016/144944, published International Application No. WO2016/145309 and published U.S. Application No. 2016/0290880, which are hereby incorporated by reference.

The electronic component **36** may be inserted into the compound **32** before curing of the tire **10** at a specific location in the tire, as will be described in greater detail below. Once the tire **10** is cured, the electronic component **36** is permanently disposed at its selected location inside the tire. Alternatively, the electronic component **36** may be inserted into the compound **32** after the tire **10** is cured and glued or secured in place by an adhesive or an interference fit. Moreover, the electronic component **36** may be employed in a new tire **10**, or in a tire that is being retreaded.

For a retreaded tire, the electronic component **36** is inserted into the compound **32** of the new tread, which may be in a flat, circular or semi-circular configuration. The new tread is bonded to the carcass to form the retreaded tire, which includes the electronic component **36**.

With reference to FIG. **3**, the electronic component **36** includes an integrated circuit **38** that processes and stores information. The electronic component **36** also includes at least one sensor **40** that is electronically connected to the integrated circuit **38**, or is integrated into the integrated circuit. Of course, multiple sensors **40** may be electronically connected to the integrated circuit **38** or integrated into the integrated circuit. The electronic component **36** preferably includes an antenna **42** for receiving and transmitting a signal to an external reader, which will be described in greater detail below. The antenna **42** is also electronically connected to the integrated circuit **38**, and may be carried on a substrate with the integrated circuit.

In this manner, the electronic component **36** includes an integrated circuit **38**, at least one sensor **40** and an antenna **42** that are integrated with one another or otherwise electronically connected. The electronic component **36** may include a modular construction to enable easy electronic connection of multiple sensors **40** or other components. In addition, the electronic component **36** may include more than one integrated circuit **38**. Because the tire **10** is designed to accommodate multiple particulate inclusions, multiple electronic components **36** may be incorporated into several locations in the tire. For example, a plurality of electronic components **36** may be incorporated into the tread compound **32** across the tread **18** and/or about the circumference of the tire **10**.

As shown in FIG. **1**, multiple electronic components **36** may be placed in desired locations as inclusions within the same tire **10** to create an array. For example, multiple electronic components **36** may be positioned circumferentially around the tire **10** at locations where stresses and heat are concentrated, such as both edges of a belt or both endings of a ply. The use of multiple electronic components **36** as an array of sensors is advantageous for structural health monitoring of the tire **10** because the temperature and stress typically are not uniform around the circumference of the belt edge or ply ending due to inevitable variations in thicknesses caused by splices and the like. Therefore, the health and/or conditions of the tire **10** typically are not uniform around the tire circumference, making it difficult to determine the location of the most adverse conditions in the tire. An array provided by multiple electronic components **36** would desirably be able to detect the point of the most adverse conditions in the tire **10**. Data from each electronic component **36** in the array preferably is communicated wirelessly, as will be described in greater detail below.

The electronic component **36** provides a desired electronic function through the use of the sensor **40** and the integrated circuit **38**, such as measuring temperature, pressure, wear, force, strain and/or acceleration of the tire **10**. For example, the sensor **40** may include one or more of at least one sensor includes at least one of a temperature sensor, a pressure sensor, a wear sensor, a force sensor, a strain sensor and an acceleration sensor or accelerometer.

In addition, as shown in FIG. **3**, the electronic component **36** may be configured to receive a radio frequency (RF) power signal and/or transmit an RF data signal using the antenna **42** and the integrated circuit **38**. Preferably, the RF signal is an ultra high frequency (UHF) signal in a range of from about 300 megahertz (MHz) to about 3 gigahertz (GHz). Moreover, the integrated circuit **38** of the electronic component **36** may include a module **44** for storing information that identifies the tire **10** through tire type, manufacturing location and the like, and/or a unique identification code, such as a tire identification (ID) code as will be described in greater detail below. The electronic component **36** optionally includes a non-rechargeable battery, rechargeable battery, supercapacitor, energy harvesting structure or wireless power receiver **50** that is integrated with or coupled to the integrated circuit **38**, as will be described in greater detail below.

Returning to FIG. **2**, the electronic component **36** may optionally be encapsulated in a rubber compound **52** that is softer than the tire tread compound **32**. For example, the encapsulation compound **52** may be a soft gum rubber. The electronic component **36** with encapsulation **52** may be inserted into the compound **32** of an uncured tire, which is then cured. Alternatively, for a tire **10** that has already been cured, a pocket may be formed in the cured compound **32**, and the electronic component **36** with encapsulation **52** inserted into the pocket. The encapsulation compound **52** protects the electronic elements in the component **36** from the mechanical forces arising in the tire **10** during operation by transmitting less force than a denser or harder compound, such as the tread compound **32**. In addition, the encapsulation compound **52** preferably is of a type that allows RF signals and/or wireless power signals as described above to pass through it, which enables efficient signal and/or energy transmission to and from the electronic component **36**.

As shown in FIG. **1** and mentioned above, the electronic component **36** may be disposed at a particular location inside the tire **10** to detect specific information. For example, the electronic component **36** may be employed to detect the temperature profiles within the tire **10** during curing. In such a case, the electronic component **36** may be disposed in the last part of the tire **10** to cure, which is referred to as the point of least cure. By being located at the point of least cure in the tire **10**, the electronic component **36** measures the actual integrated time and temperature history during the curing of the tire, which may be used to control the cycle time of the curing press. Such a measurement of actual temperature at the point of least cure of the tire **10** by the electronic component **36** is more reliable than prediction techniques. In addition, because prediction techniques often add more curing time as a precautionary factor, measurement of actual temperature may reduce the curing time that is required for the tire **10**, thereby increasing the efficiency of the curing process.

The electronic component **36** may also be employed to detect temperature within the tire **10** during its use on a vehicle. For example, the electronic component **36** may be disposed at the edge of the intermediate belts **28** in the belt reinforcement package **22** to measure the belt edge temperature. Belt edge temperature is an indicator of performance and/or life issues for the tire **10**, and by detecting temperature in the compound at the belt edge, the electronic component **36** provides data indicating when tire replacement is recommended. The electronic component **36** may also track a temperature versus time history at a specific location, such as the belt edge or a belt splice, in order to provide data to predict when tire replacement should occur. Moreover, the electronic component **36** may be disposed in a lower area of the tire sidewall **16**, at the bead area **12** and/or near the bead core **14** for temperature monitoring at a flange of a rim to which the tire **10** is mounted.

In addition, the electronic component **36** may be employed to detect wear of the tire **10** during its use on a vehicle. For example, the electronic component **36** may be

disposed in the compound **32** of the tread **18** at a specific distance from the radially outer surface of the tread. By measuring changes in electrical resistance, temperature and/or pressure, the electronic component **36** provides data indicating the amount of wear of the tread **18** of the tire **10**. Such data may be used to indicate when replacement of the tire **10** is recommended.

Moreover, the electronic component **36** may include a strain and force indicator for the tire **10** during its use on a vehicle. For example, the electronic component **36** may be disposed in the compound **32** of the tread **18** and/or in the compound of the sidewall **16**. By measuring the strain in the tread **18** of the tire **10**, the electronic component **36** may provide data indicating road conditions, and by measuring the strain in the sidewall **16** of the tire, the electronic component may provide data indicating the load on the tire. This data can be communicated to the vehicle stability and/or braking systems to provide improved control of the vehicle, and can also be used for monitoring or tracking driving behavior.

As mentioned above, the integrated circuit **38** of the electronic component **36** may include identification (ID) information for the tire **10**. The tire ID information may include manufacturing information for the tire **10**, such as: the tire type; tire model; size information, such as rim size, width, and outer diameter; manufacturing location; manufacturing date; a treadcap code that includes or correlates to a compound identification; and a mold code that includes or correlates to a tread structure identification. The tire ID information may also include a service history or other information to identify specific features and parameters of each tire **10**, as well as mechanical characteristics of the tire, such as cornering parameters, spring rate, load-inflation relationship, and the like. Such tire identification enables correlation of any of the above data with the specific tire **10** to provide local or central tracking of the tire, its current condition, and/or its condition over time. For example, Global positioning system (GPS) capability may be included to provide location tracking of the tire **10** during transport and/or location tracking of the vehicle on which the tire is installed.

Referring now to FIGS. **3** and **4**, the electronic component **36** preferably is a passive RF component that is actuated by an external reader **46**. More particularly, the electronic component **36**, including the integrated circuit **38** and the sensor **40**, remain in a passive state. When the reader **46** and is placed in proximity with the electronic component **36**, the antenna **42** receives a wireless signal from the reader through a reader antenna **48** that actuates the integrated circuit **38**. The sensor **40** takes its respective measurements, and data from the sensor measurements is communicated to the integrated circuit **38**. The data is stored on the integrated circuit **38** and transmitted wirelessly by the antenna **42** from the electronic component **36** to the reader antenna **48** and the reader **46**.

After the reader **46** is removed from proximity with the electronic component **36**, the electronic component preferably returns to its passive state. Each time that the reader **46** is placed into proximity with the electronic component **36**, the electronic component is actuated as described above. In this manner, multiple sensor measurements may be taken and stored without an ongoing power requirement by the electronic component **36**. Optionally, the electronic component **36** may include a micro-battery or an energy harvester **50** to extend the transmission range of the electronic component and/or to periodically actuate the electronic component to contact the reader **46**.

The reader **46** may be a hand-held unit or a unit that is attached to a structure in proximity with the electronic component **36**. For example, when the electronic component **36** is used to detect parameters of the tire **10** during operation of a vehicle, the reader **46** may be attached to the vehicle, including the vehicle body or a hub of a rim to which the tire is mounted. When the electronic component **36** is used to detect parameters of the tire **10** during curing, the reader may be attached on or in a center mechanism of a tire curing press. Once the data is received by the reader **46**, the reader may transmit it to the vehicle control system and/or to a device for analysis of the data. For example, the reader **46** may transmit the data to a central server for analysis, or to the cell phone of a user or technician for review.

In this manner, an article **10** such as a tire includes the electronic component **36** as a rigid electronic inclusion that is no larger than the largest particulate inclusions already present in typical tire rubber compounds. By being incorporated as an inclusion into a compound of a structure of the tire **10** at such a size, the electronic component **36** provides useful data about the tire while not adversely affecting the performance of the tire, including resistance of the compound to fatigue.

The present invention also includes a method of forming an article **10** with an electronic component **36** as an inclusion. The method includes steps in accordance with the description that is presented above and shown in FIGS. **1** through **4**.

Reference herein has been made to a tire **10** by way of example, with the understanding that the invention applies to any article that experiences repeated deformation. For example, the invention applies to any type of tires, including pneumatic tires, non-pneumatic tires, automotive tires, passenger tires, truck tires, commercial tires, off-the-road tires, aircraft tires, spacecraft tires, and the like, as well as to buildings, bridges, shoe soles, medical devices, rubber engineered products such as air springs and vibration mounts, bearings, sealants, adhesives, and the like.

It is also to be understood that the structure of the above-described tire **10** and/or the electronic component **36** may be altered or rearranged, or components or steps known to those skilled in the art omitted or added, without affecting the overall concept or operation of the invention. For example, the electronic component **36** may be disposed in any location in the tire **10** as an inclusion, any number of electronic components may be disposed in the tire **10** as inclusions, and other electronic structures may be connected to or integrated into the electronic component.

The invention has been described with reference to a preferred embodiment. Potential modifications and alterations will occur to others upon a reading and understanding of this description. It is to be understood that all such modifications and alterations are included in the scope of the invention as set forth in the appended claims, or the equivalents thereof.

What is claimed is:

1. An article with an electronic component inclusion, comprising:

at least one structural element, the structural element including a first material;

at least one electronic component being incorporated into the first material as an inclusion;

an integrated circuit being included in the electronic component; and

a second material encapsulating the electronic component, the second material being softer than the first material and being inserted into a compound of the first material.

2. The article with an electronic component inclusion of claim **1**, wherein the electronic component is up to about 2 millimeters in diameter.

3. The article with an electronic component inclusion of claim **2**, wherein the electronic component is up to about 0.5 millimeters in diameter.

4. The article with an electronic component inclusion of claim **1**, wherein the electronic component is formed by a micro-assembly technique.

5. The article with an electronic component inclusion of claim **1**, wherein the electronic component includes at least one sensor in electronic communication with the integrated circuit.

6. The article with an electronic component inclusion of claim **5**, wherein the wherein the at least one sensor includes at least one of a temperature sensor, a pressure sensor, a wear sensor, a force sensor, a strain sensor and an acceleration sensor.

7. The article with an electronic component inclusion of claim **5**, wherein the electronic component includes a modular construction with multiple sensors.

8. The article with an electronic component inclusion of claim **1**, wherein the electronic component includes an antenna in electronic communication with the integrated circuit.

9. The article with an electronic component inclusion of claim **1**, wherein the at least one electronic component includes multiple electronic components that are electrically interconnected.

10. The article with an electronic component inclusion of claim **1**, wherein the article includes a plurality of materials, and at least one electronic component is incorporated into a respective one of the materials as an inclusion.

11. The article with an electronic component inclusion of claim **1**, wherein the electronic component includes at least one of a battery, a supercapacitor, an energy harvesting structure and a wireless power receiver.

12. The article with an electronic component inclusion of claim **1**, wherein the electronic component is a passive radio frequency unit that is actuated by an external reader.

13. The article with an electronic component inclusion of claim **1**, wherein the article is a tire, the tire comprising:

a pair of bead areas;

a sidewall extending from each respective bead area to a tread, the sidewall including a compound and the tread including a tread compound;

a carcass extending toroidally between each of the bead areas, the carcass including a carcass compound; and

a belt reinforcement package disposed between the tread and the carcass, the belt reinforcing package including a belt compound; and

wherein the at least one electronic component is incorporated into at least one of the tread, carcass and belt compounds as an inclusion.

14. The article with an electronic component inclusion of claim **13**, wherein the integrated circuit includes information for identification of the tire.

15. The article with an electronic component inclusion of claim **13**, wherein the at least one of the compounds includes a plurality of electronic components incorporated into the at least one of the tread, carcass and belt compounds as inclusions.

16. The article with an electronic component inclusion of claim **13**, wherein the electronic component is inserted into the at least one of the tread, carcass and belt compounds before curing of the tire.

17. The article with an electronic component inclusion of claim **16**, wherein the electronic component is disposed at a point of least cure in the tire.

18. The article with an electronic component inclusion of claim **13**, wherein the electronic component is inserted into the at least one of the tread, carcass and belt compounds after curing of the tire.

19. The article with an electronic component inclusion of claim **13**, wherein the at least one electronic component includes a plurality of electronic components incorporated into at least one of the tread, carcass and belt compounds as a respective plurality of inclusions.

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